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SUMMARY REPORT

ON

TASK ORDER NO. I

September 2, 1958

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INTRODUCTION

In order to extend the capability of devices already in existence, the Sponsor had a need for a time-release device of some type for use in dropping leaflets from a balloon. It was necessary for such a device to be able to release ballast periodically in order to keep the balloon at a relatively constant altitude during flight. The following specifications were provided as research goals for the development of the device of interest:

(1) It should be accurate within 5 per cent over a 12-hour period in ambient temperatures ranging from -65 to 100 F.

(2) It should be extremely reliable.

(3) It should be capable of supporting and releasing from 2 to 4 pounds of leaflets.

(4) It should be capable of releasing approximately 1 pound of ballast over a 12-hour period; a constant rate of release would be acceptable, but provision for programming the rate of release would be preferable.

(5) It should function satisfactorily under the environmental conditions imposed by the flight of the balloon.

(6) It should weigh no more than 1/2 pound without ballast or leaflets.

(7) It should cost $1.50 or less per unit in lots of 10,000.

(8) It should provide for the release time for the leaflets to be adjustable in quarter-hour increments over a 3 to 12-hour period.

(9) It should have a shelf life of at least 5 years.

The work that was necessary in order to develop a satisfactory device was done in three major parts. The first part (hereafter called Phase I) was accomplished between January 2 and August 31, 1957, and consisted of the design, development, and fabrication of 30 preliminary prototype units. The second part, conducted by another contractor, was done during the Summer and Fall of 1957 and concerned the flight testing of the 30 units. The third part (hereafter called Phase II) was performed between October 1, 1957, and September 2, 1958, and comprised an investigation of selected modifications, the preparation of two modified demonstration units, and the preparation of drawings, specifications, and an operator's manual.

This report summarizes the results of the research conducted under the first and third parts of the over-all effort described above.

SUMMARY

The Phase I effort consisted of the investigation of the three major components of a time-release device, the preparation and evaluation of a design of a preliminary prototype, and the fabrication of 30 units for flight testing. The major components were the timing mechanism, the ballast-release mechanism, and the leaflet-release mechanism. After considerable investigation, it was found that the timing was best accomplished by an inexpensive clock mechanism; that suitable ballast consisted of 90 cardboard cards, one being released about every 7 minutes; and that the leaflets could be successfully dropped by a device which caused the leaflet carrier or container to upset. These components were designed into a preliminary prototype unit that was successfully tested in the laboratory and on tethered balloons. Thirty units were then fabricated and shipped to another contractor for flight-test evaluation.

The flight tests involved releasing balloons, with time-release devices and appropriate measuring and recording equipment attached, for various time periods of flight. Although an occasional malfunction was encountered, the tests showed that the basic design

was satisfactory; the preliminary prototypes successfully maintained flight altitude and accomplished the release of the leaflets. As a result of these tests, 11 minor modifications were recommended. Included in these was the feature that the device be able to detach itself from the balloon and slowly lower itself to the ground by means of a parachute.

Our subsequent research effort, under Phase II of the program, was concerned with the consideration of worth-while modifications, the fabrication of two demonstration units, the further evaluation of a possible-alternate timing mechanism, and the preparation of cost estimates. All of the recommended modifications, together with others which were conceived subsequently, were incorporated in a modified design. Two units were then prepared on the basis of this design and submitted to the Sponsor; supporting stands were also provided, so that the assembly and operation of the device could be easily demonstrated.

Cost estimates for the commercial production of the time-release device in lots of 10,000 and 25,000 units were prepared on the basis of estimated figures as well as prices obtained from actual bids provided by commercial fabricators. In these lots, the estimated cost of this device (with the parachute assembly not included, in accord with a discussion with the Sponsor) was $3.16 to $3.27. We believe that, if actual production were undertaken, the cost of the device would closely approach the modified acceptable figure of $2.50 per unit.

The possible-alternate timing unit (the King-Seeley timer) successfully passed all of the laboratory tests. However, the application of this unit to the time-release device would necessitate several major changes in the configuration of the device.

Specifications and drawings, and an operator's manual were prepared and submitted to the Sponsor.

ENGINEERING ACTIVITY

As described above, the engineering activity consisted of Phases I and II which were conducted by our organization under Task Order No. I, and the flight tests which were performed by another contractor. The work under all three parts is described in some detail herein, so that a clear picture of the development activities can be presented readily.

PHASE I

The procedure for the development of the preliminary prototype consisted of first, evolving, investigating, and selecting designs for the major components of the device; second, preparing detailed drawings of the preliminary prototype; and, third, evaluating the design and fabricating 30 units.

Investigation of Major Components

The efforts to meet the requirements were concerned essentially with three major components: (1) a component to permit proper timing for payload (leaflet) release, (2) a component to accomplish periodic release of the ballast, and (3) a component to provide for release of the leaflets.

Timing Component

To provide a good basis for uncovering an inexpensive method or mechanism to time the release of the ballast and of the leaflets, a literature search was made and several idea conferences were conducted. Clock-type escapement mechanisms were suggested for this purpose, with the motive power being supplied by the weight of the payload. Sand, shot, or other particulate matter flowing through an orifice was proposed not only to time an interval, but also to serve as a means for ballast release. Another method conceived for timing was the controlled evaporation of fluids; again, this method could be used to effect both ballast release and leaflet release.

Evaporation. To employ evaporation as a means of timing, a vessel with some apparatus for the control of the evaporation rate would be necessary. Since the rate of evaporation of a liquid is dependent upon the temperature, the Reynolds number of the air above the liquid, and the Reynolds number of the liquid at the interface, an appropriate apparatus would have had to control one or more of these factors. The control of these factors, in all probability, would have required mechanisms which would have caused the weight and cost of the device to exceed the stated requirements. Therefore, evaporation of liquids as a method for controlling timing and also ballast release was abandoned.

Particulate Materials. Several ideas were conceived regarding the use of sand and other particulate material for timing and for ballast release. These ideas were evaluated experimentally. Screened sands were obtained and the weight rate of flow of sands of various sizes through different-sized orifices was determined. Unfortunately, with the finest available sands, the smallest weight rate of flow in a 12-hour period involved more than 10 times the maximum weight of ballast to be released. When smaller orifices were used, the flow of sand was erratic because the sand would frequently bridge above the orifice. Similar experiments with other particulate materials such as finely divided silica, stainless steel, plastic, and glass showed substantially the same results.

As the minimum rate of flow achieved practically was so much larger than the required rate, further investigation of the flow of sand or other particulate matter through orifices was abandoned.

Escapement Mechanisms. Of the ideas conceived for timing, only the escapement-type mechanisms appeared to be practicable. There are many kinds of escapement mechanisms. Perhaps only 12 to 15 types of such mechanisms are in current commercial use. As low cost was a prerequisite for the timer component, various escapement mechanisms that were currently used in inexpensive clock movements were examined.

In this study, 11 clocks and 2 timers were purchased, disassembled, and examined. The names of the mechanisms studied and of the manufacturers are given in Appendix 1. The escapements were of two general types: verge, and pawl-wheel-lever types. The verge timer had fewer parts than the pawl-wheel-lever timer and probably represented a less expensive mechanism. Therefore, in spite of the fact that the verge timer was thought to be less accurate than the other type, both types of mechanisms were experimentally investigated.

This investigation was directed toward determining if the mechanisms would time intervals with sufficient accuracy, if the maximum and minimum torques required to operate the mechanisms could be tolerated, and if the mechanisms would operate satisfactorily at temperatures as low as -65 F.

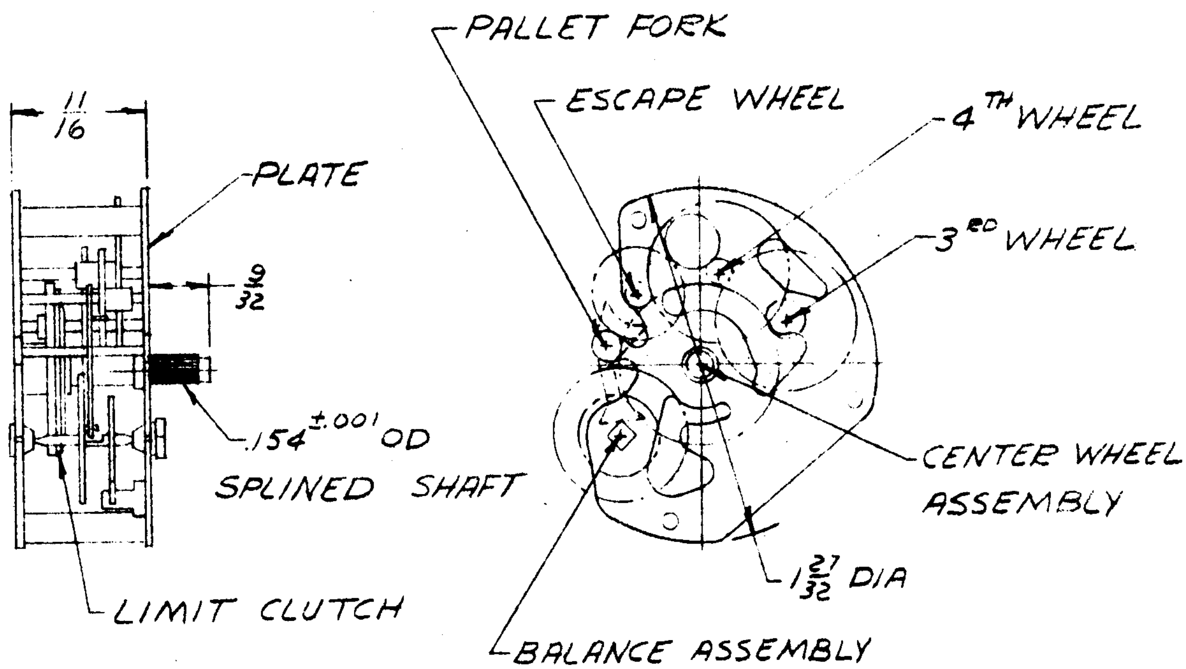
For the experiments conducted, all of the parts of the purchased clocks and timers except those in the timing mechanisms were removed from each unit. In each instance, the parts retained were the escapement; the reduction gears connecting the output of the escapement to the output shaft, which rotated at the rate of 1 revolution per hour; and a frame to retain the parts.

Each mechanism was mounted on a steel plate and a cord was wrapped about the output shaft. Weights were applied to the end of the cord in order to drive the timer; different weights were successively applied, to determine the maximum and minimum torques which would operate each timer, at room temperature and at -65 F. In this way, the timing accuracy of each device was determined for various driving torques.

The results of these experiments showed that several of the mechanisms timed with sufficient accuracy, but, that only one, the unit from a Lux Minute-Minder shown in Figure 1, operated over a satisfactorily wide range of torques. It was also found that this unit was the only one which would operate at temperatures as low as -65 F; it was necessary to thoroughly degrease and lubricate this mechanism with dry graphite powder in order to achieve operation at that low a temperature.

A visit was made to the Lux Clock Manufacturing Company, Waterbury, Connecticut, to survey the potential procurement situation with regard to timers similar to those evaluated. An estimate of $1.30 per unit was given by Lux for the timer of interest. When Lux was told that this cost was too high in view of the over-all cost requirement, they suggested that subsequent consideration might enable them to reduce the price. Since the Lux movement was the only one of the units evaluated that was capable of the required performance, the Sponsor agreed that the target cost for the complete time-release device could be raised from $1.50 to $2.50.

Consequently, a timing unit made of parts from the Lux Minute-Minder works was chosen for application in the preliminary prototype of the device. The output shaft or the shaft designed to rotate at the rate of 1 revolution per hour was selected to drive a ballast-release mechanism and to initiate leaflet release. The



NOTES:

1. ALL DIMENSIONS IN INCHES.
2. Nº REQ'D — 1 PER ASSEMBLY D-19-A4.
3. PARTIAL LUX TIMER MOVEMENT MODEL #2428 OR EQUIV.
4. MAXIMUM WEIGHT - 1 1/8 OUNCES.
5. ALL PARTS TO BE CLEANED THOROUGHLY, AND THEN COATED WITH FINE, DRY, POWDERED GRAPHITE LUBRICATING FLAKES.

FIGURE 1. TIMING MECHANISM CONSISTING OF PARTS FROM THE LUX MINUTE-MINDER

driving force for the unit was to be provided by the weight of the leaflet load acting on a drive cord wound around the output shaft.

Ballast-Release Component

In general, there were several considerations involved in the selection of a suitable ballast material and method for ballast release that would satisfy the previously stated specifications; these included: (1) the reservoir for the ballast, (2) the ballast feed from the reservoir to the release point, (3) the ballast-release mechanism, (4) the power required to operate the mechanism, and (5) the effect on ground personnel if struck by falling ballast. For use in connection with the many ideas conceived for ballast supply, feed, and release, the practicable materials appeared to be plastic, paper, liquids, metal shot, and sand or similar particulate materials. A discussion of various methods of achieving ballast release is included in the following.

Evaporation. As described above, the utilization of evaporation of liquid ballast appeared to be impracticable for timing purposes, but an advantage inherent in the use of liquid ballast was the ease with which it could be handled. For instance, a liquid could be contained in a plastic tube and released as the tube was collapsed by the action of the timing unit. However, the cost per pound of a liquid which would not freeze at -65 F was greater than that for any of the other materials considered. Therefore, further consideration of liquid as a ballast was set aside until the possible application of other materials had been investigated.

Particulate Materials. The possible use of metal shot, sand, or other particulate materials carried with it relatively difficult handling problems. In this connection, a pre-formed tape was suggested for use in retaining the ballast in a coil which could be released by the action of the timing unit. Also, a mechanism was proposed to expel the shot from pockets in the tape. Similar mechanisms were conceived to release shot or particulate materials from reservoirs. One unit of this general type was designed, fabricated, and evaluated; this consisted essentially of a cylindrical reservoir which, in the almost-horizontal position, was rotated by the action of the timing unit. Eight generally longitudinal troughs were located on the interior cylindrical surface. As the cylinder rotated, each trough would pass through the mass of shot reposing in the reservoir, pick up eight pieces of shot, and discharge them through an opening at the upper part of the outboard end of the cylinder. As the troughs were equally spaced around the interior cylindrical surface, this action would expel the given number of shot at definite intervals.

This unit was evaluated in the laboratory; the ballast was expelled at a rate which was sufficiently uniform to meet the specifications. However, when this ballast-release mechanism was experimentally flight tested while suspended from a balloon, the violent agitation which occurred during flight caused the shot to be prematurely dislodged from the troughs. The resulting rate of ballast release was erratic and unsatisfactory.

Cards. Another method of ballast release considered involved the release of cards prepared from paper or plastic. Square thin cards with a hole punched in one corner were assembled vertically into a regularly slotted plate. The cards protruded above the plate far enough to permit a nylon cord to be threaded through the holes and thus retain the cards in the slots. One end of this nylon cord was attached to the output shaft of the timing mechanism. As this shaft rotated, the cord was wound on the shaft and simultaneously drawn through the holes in successive cards. Thus, this action released the cards, at regular intervals.

To evaluate this ballast-release mechanism under simulated flight conditions, a mock-up was fabricated and "flown" beneath two tethered balloons (Figures 2 and 3). As in the previous simulated flight experiments, the mechanism was violently shaken. Some slight damage to the cards occurred due to the cutting action of the nylon cord in the holes; however, the use of thicker cards minimized this difficulty. The rate of ballast release achieved with this mechanism during simulated flight was believed to be satisfactory.

Leaflet-Release Component

The third major component of the device represented the mechanism for releasing the leaflets. The Sponsor had indicated that generally, to conduct an operation, the leaflets would be packed in a container or carrier of some type, and ultimately would be dumped out of the top of the carrier. Thus, in order for this component to

N56005A

Figure 2. Unit Used in Ballast-Release Experiments

N56005B

Figure 3. Flight Evaluation of Ballast-Release Mechanism

provide for release of the leaflets, it would have to disengage the loaded carrier from the balloon at least temporarily, and then expel the leaflets from the carrier.

To achieve the proper over-all performance, some action, condition, or event had to be used to actuate carrier disengagement and leaflet expulsion. There were two convenient events or conditions which appeared to be exploitable: the conclusion of the timed interval, and the slack which would occur in the drive cord some time during the release operation.

To provide a method for release of the load, a pin was attached to the output shaft of the timing mechanism. A loop at one end of the drive cord was placed around the shaft and a second small loop, approximately 6 inches along the cord, was placed over the pin. The intervening 6 inches of cord was then tucked loosely about the shaft. Figure 4 shows the installation at this stage. Then, the part of the drive cord beyond the small loop was wrapped around the shaft, one complete wrap corresponding to one hour of operation of the timer (Figure 5). A third loop in the drive cord was secured to the load-release hook (described below), and the other end of the drive cord was attached to the bottom of the leaflet carrier. Thus, at the end of the timed interval when the drive cord was paid out, the small loop would slip off the pin of the output shaft; this action would permit the load to fall freely through a short distance and would actuate the load-release hook. After the 6 inches of slack in the drive cord was taken up, the drive cord would abruptly arrest

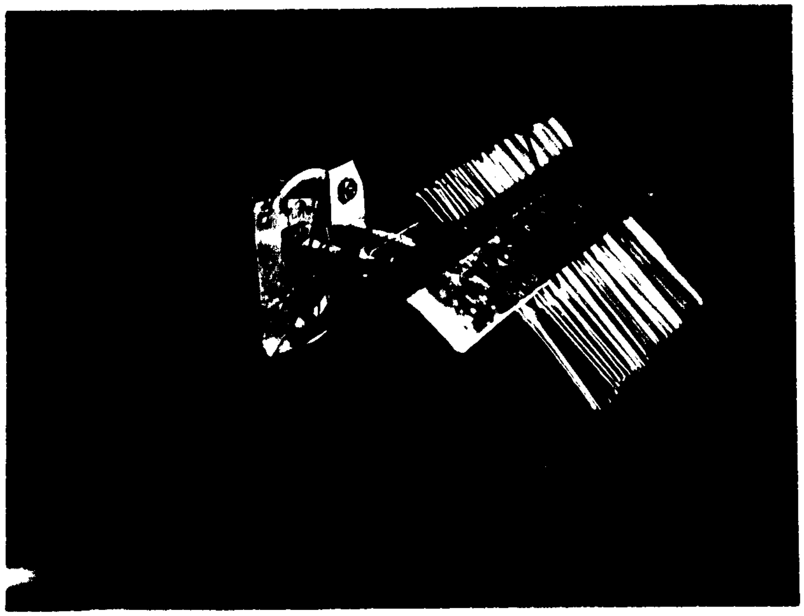


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Figure 4. First Step of Drive-Cord Installation

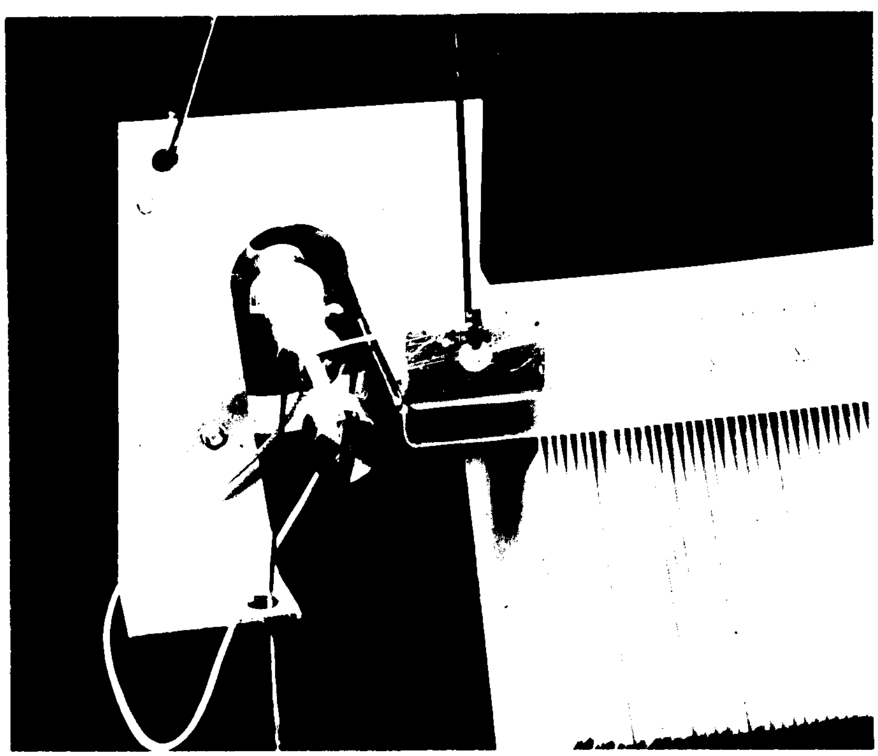

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Figure 5. Second Step of Drive-Cord Installation

the fall of the load (the carrier containing the leaflets) and upset the carrier so as to expel the leaflets.

Three different hooks were developed for use in temporarily freeing the carrier so that it could be upset. Each of these hooks operated so as to temporarily release the cords attached to one side of the carrier when the tension in the drive cord was relieved. Two of these hooks were found to be the most reliable. Each was incorporated into 15 of the 30 preliminary prototype devices.

Preliminary Prototype Design

The above-described effort resulted in workable major components, which were subsequently incorporated into a satisfactory over-all device. This unit, the preliminary prototype time-release device, consisted of seven primary parts. These were: a mechanical timer, a drive shaft, a timer chassis, a ballast rack, ballast, a load container, and associated wire and cord parts, which are illustrated in Figure 6.

In this design, the timer chassis functioned as the main structural member, with the timer, ballast rack, and other parts being attached to it. The ballast rack was riveted to the chassis to form a permanent attachment. The other parts were fabricated so that they could be easily assembled in the field.

The load container, which would carry the leaflets, was connected to the drive shaft of the timer by means of the drive cord. This cord was wrapped around the drive shaft and actuated the timer movement by exerting a torque on the drive shaft by means of the

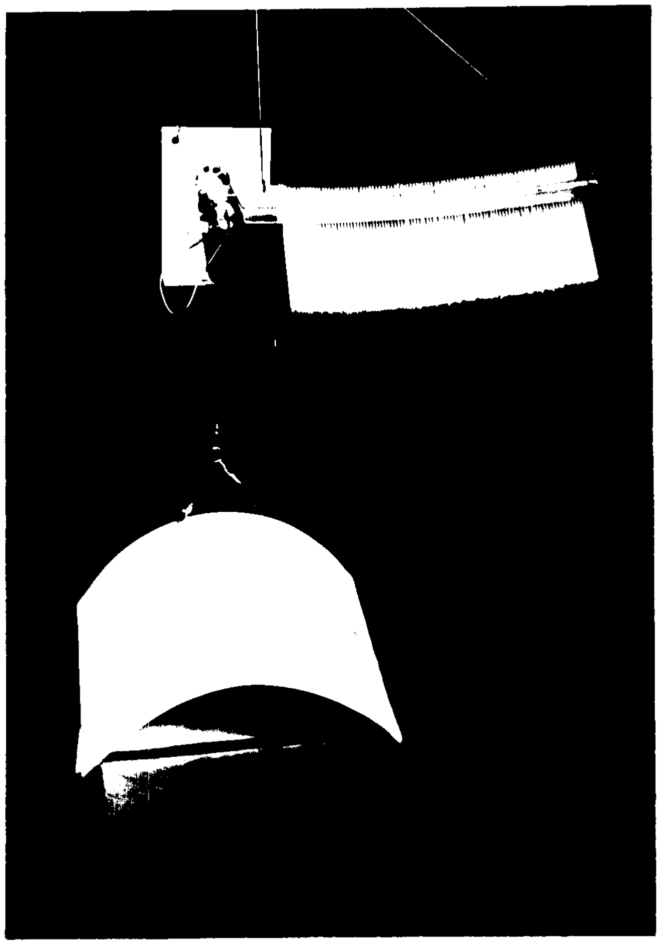

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Figure 6. Preliminary Prototype Time-Release Leaflet Carrier

weight of the load (container plus leaflets). The timer regulated the rate of rotation of the drive shaft.

The ballast-release mechanism included the ballast rack, ballast cards, and the ballast-release cord. This cord was threaded through holes punched in one corner of each ballast card and was fastened at one end to the drive shaft. As the drive shaft rotated, the ballast-release cord was wound around this shaft, and simultaneously the free end of the ballast-release cord was pulled through the holes in the ballast cards. This action permitted the ballast cards to be freed at the approximate rate of 1 card every 7-1/2 minutes.

A 12-hour indicating scale was located along one edge of the ballast rack; the scale was divided into 15-minute increments, to facilitate the presetting of the desired flight time. Prior to release of the unit for flight, 12 full turns of drive cord were wound around the drive shaft, and the ballast-release cord was threaded through the holes in the ballast cards. Any excess ballast-release cord was cut off with a sharp instrument at the 12-hour mark on the ballast rack. The device was then ready for a 12-hour operation. If a flight time of less than 12 hours was desired, then the drive shaft was rotated in a counterclockwise direction until the cut end of the ballast-release cord was opposite the desired-flight-time mark as indicated on the flight-time scale of the ballast rack.

After the device had operated for the preset period of time, the drive cord was fully unwound from the drive shaft and slipped off the drive-shaft pin; thus, it permitted the load container to fall freely through a distance of a few inches. During this period of free fall, the load-release mechanism temporarily freed the load-container support line, and caused the load container to upset and dump the leaflets.

Evaluation experiments showed that this unit operated satisfactorily in all respects except that the ballast-card-drop interval varied more than had been expected - as much as ±1 minute. However, since the effect of this variation under service conditions was not readily apparent, the decision was made mutually to proceed with the fabrication of the units for subsequent flight testing.

Preliminary Prototype Fabrication

As outlined in our original proposal included in our letter dated October 12, 1956, the effort was to include the preparation of a small number of preliminary prototype units. This proposal was modified in our letter dated November 13, 1956, to include the preparation of up to 30 preliminary prototype devices.

After the laboratory evaluation of the experimental device was completed, 15 prototype models were prepared and shipped to the Sponsor on July 20, 1957, for field testing. During the following month, 15 additional prototype devices were prepared and delivered to the Sponsor for field testing. The second lot of 15 devices was identical with the first except that the load-release hook was of a different design.

FLIGHT EVALUATION PROGRAM

At the close of Phase I of this research program, the preliminary prototype time-release devices were transmitted by the Sponsor to another contractor for the flight evaluation program. In a series of programmed balloon test flights, small payloads including suitable measuring and recording equipment were dropped at previously selected target areas using the time-release devices. In each of the series of planned balloon flights, the selected target areas varied in distance from the launching site.

For the device to be acceptable, the performance of two primary functions had to be demonstrated. First, the device had to be capable of maintaining a proper flight altitude as a result of the periodic release of the card ballast. This function proved to be satisfactory in approximately 35 flight tests. The second function to be performed was the dropping of the leaflet load after the predetermined and preset time had elapsed. It was found that this function also was performed.

As shown by their report, the other contractor found the time-release device to be well suited to the delivery of leaflets by means of balloons. However, on the basis of the results of the flight evaluation program, certain design modifications were recommended for consideration. These are outlined below:

(1) Provide a more secure means of attaching the ballast-release cord to the wind-up portion of the drive shaft.

(2) Increase the length of the ballast-release cord to approximately twice the length of the ballast rack.

(3) Eliminate the slack portion of the drive cord that extended from the drop-off loop on the drive pin to the securing loop that was attached to the drive shaft.

(4) Provide a snubber line to halt the free fall of the leaflet carrier; this line should also actuate a disconnect hook (See Item 5, next).

(5) Provide a disconnect hook so that the entire time-release device could be completely separated from the balloon subsequent to release of the leaflets.

(6) Provide a small parachute to retard the fall of the device after it was separated from the balloon.

(7) Provide a time-indicating scale at the outer end of the ballast rack, to show where the ballast-release cord should be severed in order to achieve various periods of time delay (between the instant the timer was started and the instant the first ballast cord dropped).

(8) Eliminate the first six card slots at the outer end of the ballast rack and thus provide 90 instead of 96 slots in the ballast rack.

(9) Provide radial markings on the timer chassis to facilitate incremental positioning of the drive shaft; these marks were to indicate 10- or 15-minute intervals of flight-duration time, with the drive pin acting as a pointer.

(10) Provide a means of attaching the ballast rack to the timer chassis that would enable the operator to perform this assembly operation readily.

(11) On a practical basis, convert and adjust, when advisable, the dimensions of the components to the metric system.

PHASE II

As indicated previously, the second phase of this research program was directed toward the consideration of selected design modifications, the preparation of two prototype devices, the testing of an alternate timer, the preparation of specifications, drawings, and an operator's manual, and an estimation of the costs of manufacturing the prototype in production lots. These various activities are discussed below.

Preliminary-Prototype Modification

During the consideration of the modifications recommended by the flight-testing contractor, a few other desirable modifications became apparent. These changes, as well as those listed above, were investigated. In the below-presented description of the modification effort, the item numbers corresponding to the modifications as listed above are included in the text. To facilitate comprehension of the rather detailed description, it is suggested that reference be made to Figures 6 and 7.

Modifications Recommended by the Flight-Test Contractor

The ballast-release cord in the design of the preliminary prototype was attached to the drive shaft by hooking the knotted end through the slotted flange, and then looping the cord around the drive shaft. In several of the flight tests, the knotted end of the ballast-release cord slipped from the flange slot and caused a malfunction of the ballast-release mechanism (Item 1). To eliminate this difficulty, a hole was drilled through the drive shaft and this, instead of a slot in the flange, was used to retain the knotted ballast-cord end.

In the flight tests, it had been determined that the initial balloon lift often resulted in the balloon "overshooting" in altitude. This overshooting resulted in a delay period of from several minutes to an hour or more, depending on the load and the balloon size, before the balloon attained comparatively level flight.

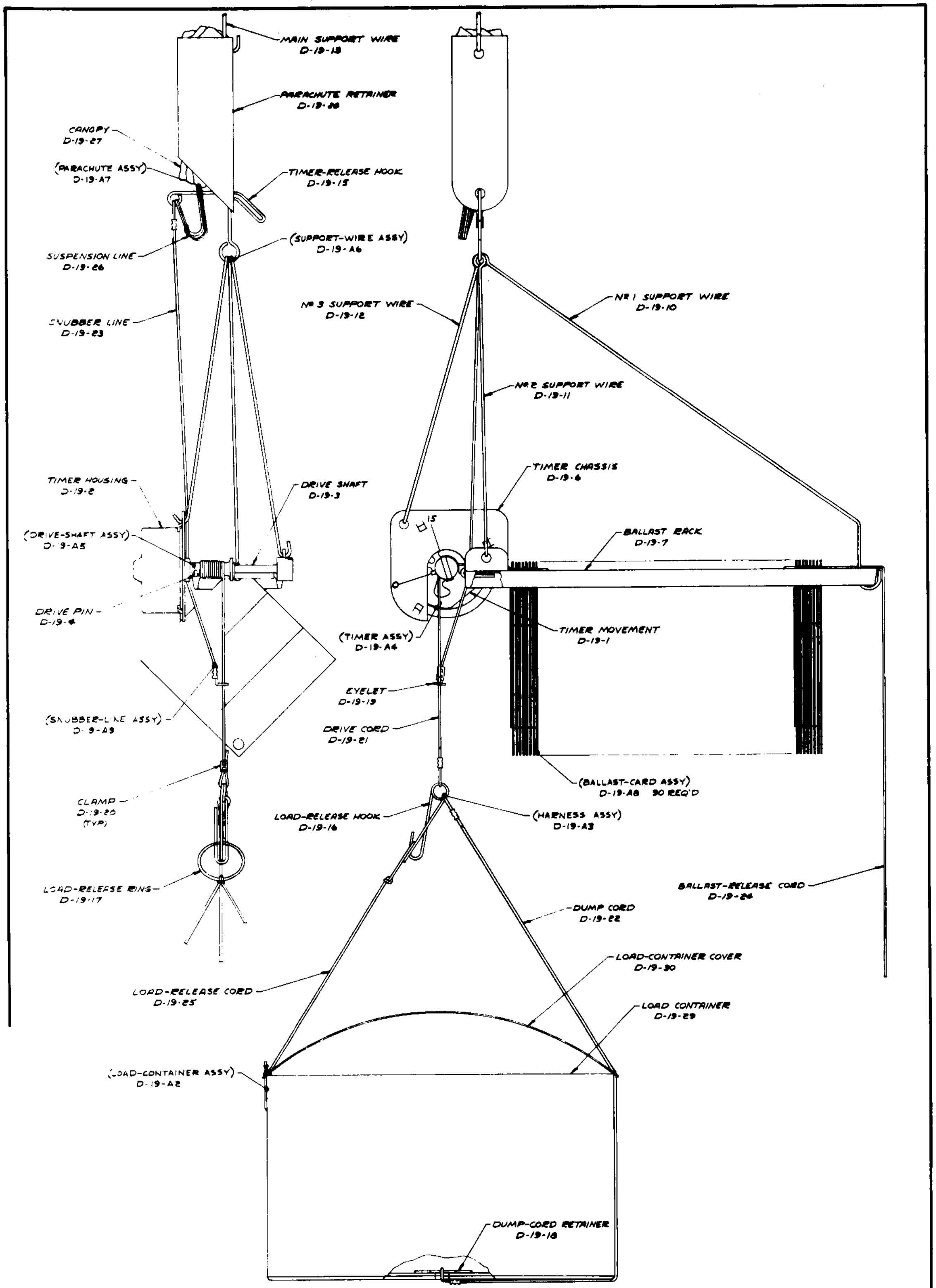

FIGURE 7. THE TYPE I TIME-RELEASE LEAFLET CARRIER ~ MAIN ASSEMBLY

During this leveling-out period, the release of ballast is unnecessary. Consequently, the length of the ballast-release cord (Item 2) was increased as recommended, so as to provide for a delay time before the release of the first ballast card.

In this same connection, there was a need for a scale at the outer end of the ballast rack that would facilitate setting the delay time for a specific flight (Item 7). A scale was added that was divided into 15-minute increments and provided for a maximum delay time of 90 minutes. Further, without the need for ballast release in the early stages of a flight, it was apparent that all 96 of the ballast cards were not necessary for proper ballast adjustment (Item 8). Therefore, as recommended by the Sponsor, the first six slots in the ballast rack and the corresponding cards were eliminated.

In some of the flight tests, the slack portion of the drive cord between the drop-off loop and the securing loop entered the opening of the timer housing and fouled the timer movement (Item 3). The function of this drop-off loop has been described. In order to prevent this fouling difficulty and to maintain the free-fall and dumping feature of the over-all device, the securing loop and the slack portion of the drive cord were eliminated, and another line with an attached eyelet was added to supplement the drop-off loop. This new line, the snubber line (Item 4), also functioned to release the entire time-release device from the balloon after the leaflet load was dumped. As shown in Figure 7, the top end of the snubber line (i.e., the end opposite the eyelet end) was attached to the timer-release hook (Item 5). When the preset time interval had elapsed, the drive-cord drop-off loop slipped off the drive pin; the drive cord with the attached load fell freely for a short distance, and then the free fall was arrested as a result of the drop-off loop catching in the snubber-line eyelet. This action caused a downward force to be exerted on the snubber line; this pull activated the timer-release hook and resulted in the device being disengaged from the balloon, as described below.

The downward force that activated the timer-release hook also pulled the canopy of the parachute free from the parachute retainer (Item 6). The parachute assembly, attached by the suspension cords to the timer-release hook, then retarded the fall of the attached assembly. The primary function of the parachute assembly was to lessen the hazard represented by the falling time-release device dropping onto personnel on the ground.

As indicated under Item 9, the full utility of the time-release device could be better realized if the timer movement could be preset more accurately than was possible by using only the markings provided on the ballast rack. Radial marks (Figure 7) indicating 15-minute time increments were provided on the timer chassis, with the drive pin functioning as the pointer for settings of 15- and 30-minute increments. To permit setting for a 45-minute increment, a line was embossed diametrically opposite the drive pin on the drive shaft; to make this setting, the drive shaft is rotated so as to position this line opposite the 15-minute mark.

In the preliminary prototype device, the ballast rack was permanently attached to the timer chassis by means of two rivets (Item 10). This subassembly, due to its irregular configuration, presented problems in regard to packaging and storage. These difficulties were eliminated by providing a U-shaped clamp on the timer chassis, so that the ballast rack could be easily snapped into position under service conditions (Figure 7).

In an effort to confuse attributability considerations by personnel who ultimately would pick up the time-release device (after an operation had been completed), all dimensions, where practicable, were converted or adjusted to the metric system (Item 11).

Additional Modifications

In addition to the 11 listed modifications, several others were included in this research effort on the basis of mutual consideration.

The diameter of the portion of the drive shaft that was used to wind up the ballast-release cord was increased from 0.153 to 0.160 inch (4.06 mm). The purpose of this change was to provide a more accurate relationship between the minute increments as indicated by the scale on the timer chassis and the hour increments as indicated by the scale on the ballast rack.

Improved ballast racks were prepared by a compression-molding process. The original ballast racks were cast from a thermosetting plastic; these were quite fragile and relatively expensive. In the compression-molding process, the two-part mold is preheated, and subsequently the plastic resin which has been added is compressed between the two mold halves to form the desired part. This process is somewhat similar to injection molding. The background of our Rubber and Plastics Chemistry Division, coupled with the experience gained in compression molding ballast racks, has provided information pertaining directly to the selection of a plastic resin and method to be used in the commercial production of this part. One type of resin, a modified polystyrene called Cycolac, proved to be an outstanding material for molded ballast racks, both from the standpoints of resistance to shock and ease of molding.

By a redesign of the timer housing so that notches in the housing could be aligned with stamped lugs on the timer chassis, three screws and three threaded holes were eliminated. This feature also eliminated the need for an additional assembly tool for field use.

A cost estimate showed that the drive shaft, drive pin, and set screw that were incorporated in the preliminary prototype design would cost approximately $0.85. It appeared that the cost of these items could be greatly reduced if the design were modified to provide for a molded plastic drive shaft to be pressed onto the splined end of the timer mainshaft. Consequently, drive shafts were machined from Lucite, Cycolac, and nylon, and these were evaluated cursorily for tensile and torsional strength under actual operating conditions. Nylon proved to be the only material that provided enough torsional strength at the smallest-diameter section of the drive shaft. The estimated price per shaft, when injection molded, was $0.055.

Fabrication of Two Modified Units

Two Type 1 Time-Release Leaflet Carriers were prepared for evaluating the performance of the device modified in accord with all of the above changes, except for the plastic drive shaft, prior to the preparation of the specifications, drawings, and operator's manual. Each of the two devices was subjected to laboratory tests to assure that the modifications were functional under simulated-flight conditions. Their performance was satisfactory. The units were subsequently shipped to the Sponsor, along with support stands, which could be used to demonstrate readily the assembly and operation of the device. An assembled unit is shown in Figure 8.

The weight of a completely assembled unit was 750 grams (1.6 pounds). Of this, the 90 ballast cards weighed 410 grams (0.9 pound), the load container and cover 170 grams (0.4 pound), the parachute 15 grams (0.03 pound), and the other parts of the unit 155 grams (0.3 pound). For additional details with regard to the Type 1 Time-Release Leaflet Carrier - parts, materials of construction, method of manufacture, assembly procedure in the field, or operating procedure - please refer to the manufacturing, inspection, and packaging specifications, and to the operator's manual furnished to the Sponsor (see below).

Cost Estimates

One basic consideration throughout this program was the commercial-production cost of the time-release leaflet carrier in

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Figure 8. Demonstration Model of Type 1 Time-Release Leaflet Carrier

quantities of 10,000 and 25,000. To provide the Sponsor with approximate cost figures for this device, a cost estimating study was conducted during the course of the project.

Toward the end of the project and after the two above-mentioned units had been prepared and evaluated, it became particularly apparent that the estimated production cost for the unit was too high. After a discussion with the Sponsor, it was mutually agreed to eliminate the parachute assembly and to adopt the redesigned drive shaft (involving the change from machined metal to molded plastic, etc., as described above). These two measures resulted in an estimated-cost reduction of $0.57 and $0.74, respectively, per unit.

At one stage of the research, it appeared that there might be some difficulty in obtaining paper ballast cards at the price which was first estimated. In an attempt to obtain cheap ballast cards, considerable effort was spent on the consideration of plastic and metal cards, and on the estimation of costs. However, a firm was found that substantiated our original estimate of the cost of paper ballast cards; consequently, consideration of the other materials for ballast cards was discontinued.

Listed in Tables 1 and 2 are the estimated costs of the various parts and of the device, as well as of assembly effort, for lots of 10,000 and 25,000 units, respectively. It is to be noted in the tables that some of the prices are estimated costs and others are based on actual bids.

It is recognized that the indicated estimated cost of $3.16 to $3.27 is higher than the $2.50 specified. However, we

TABLE 1. ESTIMATED COSTS FOR THE COMMERCIAL PRODUCTION OF THE TYPE 1 TIME-RELEASE LEAFLET CARRIER IN LOTS OF 10,000

Part	No. Required	Cost per 1,000 Devices*	Cost Each	Total Cost per Device	Source of Data
Timer Movement + Timer Housing	1	$1,110.00	$1.11	$1.11	Bid
Drive Shaft	1	55.00	.055	.055	Bid
Timer Chassis	1	110.00	.11	.11	Bid
Ballast Rack	1	155.00	.155	.155	Bid
Ballast Card	90	928.80	.0103	.927	Bid
No. 1 Support Wire	1	38.00	.038	.038	Bid
No. 2 Support Wire	1	25.90	.026	.026	Bid
No. 3 Support Wire	1	23.50	.024	.024	Bid
Support Wire Assembly	(Labor)	54.80	.055	.055	Estimate
Main Support Wire	1	29.80	.030	.030	Bid
Timer-Release Hook	1	45.50	.046	.046	Bid
Load-Release Hook	1	71.00	.071	.071	Bid
Dump-Cord Retainer	1	14.75	.015	.015	Bid
Load-Release Ring	1	22.65	.023	.023	Bid
Threading Needle	1	24.75	.025	.025	Bid
Drive Cord	1	18.90	.019	.019	Estimate
Dump Cord	1	17.30	.017	.017	Estimate
Ballast-Release Cord	1	20.00	.020	.020	Estimate
Load-Release Cord	1	40.90	.041	.041	Estimate
Harness Assembly	(Labor)	138.80	.139	.139	Estimate

TABLE 1. (Continued)

Part	No. Required	Cost per 1,000 Devices*	Cost Each	Total Cost per Device	Source of Data
Snubber Line	1	14.10	.014	.014	Estimate
Snubber Line Assembly	(Labor)	39.20	.039	.039	Estimate
Eyelet	1	20.00	.020	.020	Estimate
Clamp	5	70.00	.014	.07	Estimate
Load Container	1	66.60	.067	.067	Bid
Load-Container Cover	1	44.50	.045	.045	Estimate
Load-Container Assembly	(Labor)	66.70	.067	.067	Estimate
Total		$3,266.45		$3.266	

*Based on the estimated cost in lots of 10,000.

TABLE 2. ESTIMATED COSTS FOR THE COMMERCIAL PRODUCTION OF THE TYPE 1 TIME-RELEASE LEAFLET CARRIER IN LOTS OF 25,000

Part	No. Required	Cost per 1,000 Devices*	Cost Each	Total Cost per Device	Source of Data
Timer Movement + Timer Housing	1	$1,050.00	$1.05	$1.05	Bid
Drive Shaft	1	55.00	.055	.055	Bid
Timer Chassis	1	110.00	.110	.11	Bid
Ballast Rack	1	155.00	.155	.155	Bid
Ballast Card	90	877.50	.0098	.878	Bid
No. 1 Support Wire	1	38.00	.038	.038	Bid
No. 2 Support Wire	1	25.90	.026	.026	Bid
No. 3 Support Wire	1	23.50	.024	.024	Bid
Support Wire Assembly	(Labor)	54.80	.055	.055	Estimate
Main Support Wire	1	29.80	.030	.030	Bid
Timer-Release Hook	1	45.50	.046	.046	Bid
Load-Release Hook	1	71.00	.071	.071	Bid
Dump-Cord Retainer	1	14.75	.015	.015	Bid
Load-Release Ring	1	22.65	.023	.023	Bid
Threading Needle	1	24.75	.025	.025	Bid
Drive Cord	1	18.90	.019	.019	Estimate
Dump Cord	1	17.30	.017	.017	Estimate
Ballast-Release Cord	1	20.00	.020	.020	Estimate
Load-Release Cord	1	40.90	.041	.041	Estimate

TABLE 2. (Continued)

Part	No. Required	Cost per 1,000 Devices*	Cost Each	Total Cost per Device	Source of Data
Harness Assembly	(Labor)	138.80	.139	.139	Estimate
Snubber Line	1	14.10	.014	.014	Estimate
Snubber Line Assembly	(Labor)	39.20	.039	.039	Estimate
Eyelet	1	20.00	.020	.020	Estimate
Clamp	5	70.00	.014	.07	Estimate
Load Container	1	66.60	.067	.067	Bid
Load-Container Cover	1	44.50	.045	.045	Estimate
Load Container Assembly	(Labor)	66.70	.067	.067	Estimate
Total		$3,155.15		$3.155	

*Based on the estimated cost in lots of 25,000.

believe that the specified figure could be approached closely if actual production were undertaken.

King-Seeley-Timer Evaluation

In the development of the time-release device, only one of the several "clock-type" timing mechanisms evaluated proved to be satisfactory for the application. The Sponsor could not always be assured of the availability of the timer movement in such a sole-source situation. Consequently, the Sponsor shipped us three King-Seeley timers for evaluation. It was hoped that this type of unit would serve as an alternate timing movement for the time-release device.

In the latter part of Phase I of this project, a cursory evaluation of the King-Seeley timer was conducted. Under Phase II, a further evaluation of this timer was performed.

The three King-Seeley timers were subjected to cold-box tests at -65 F. As shown in Figure 9, the timers were mounted on a panel with weighted cords looped around the timer drive shafts. Two of the movements had not been previously cleaned or adjusted. The other movement had been cleaned, to remove all oil and grease lubricants; the unit had been washed in a solution of Tide (a household detergent) and hot water, rinsed in hot distilled water, and allowed to dry. This cleaned timer movement had then been lubricated, on all bearing surfaces, with a flake graphite lubricant.

The two movements in the as-received condition ran intermittently for a period of about 3 hours and then stopped. The cleaned and relubricated movement ran continuously until the drive cord

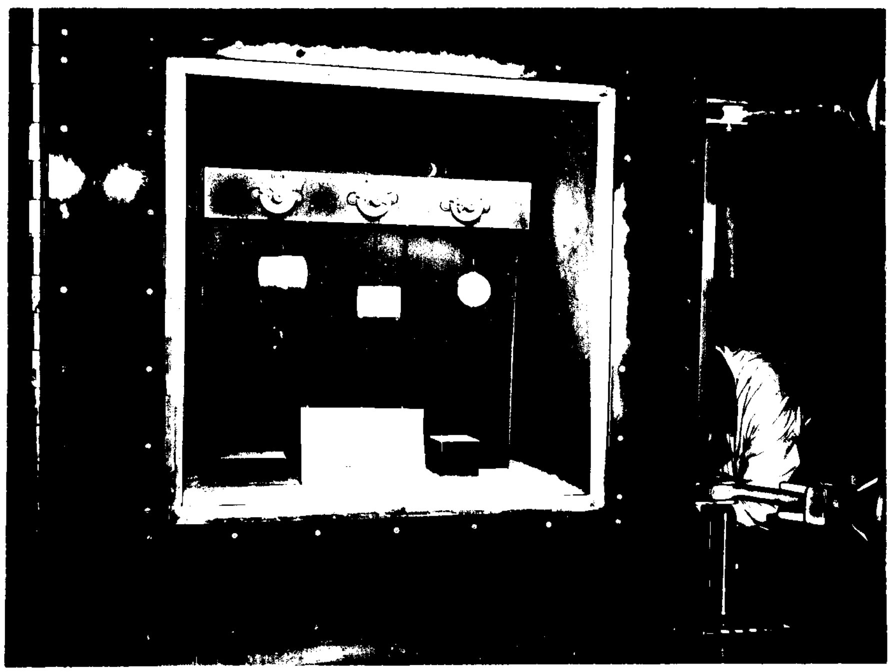

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Figure 9. Cold-Temperature Tests of King-Seeley Timers

completely unwound from the drive shaft. The two as-received units were then cleaned in a hot Tide-water solution, rinsed, dried, and lubricated with graphite flakes. In all of the subsequent tests, these timer movements functioned for more than 12-hour periods at -65 F without stoppage.

On the basis of the data obtained from these cold-box tests, it appears that the King-Seeley timer operates satisfactorily under the conditions involved in the application of interest. However, the mainshaft of this unit rotates in a clockwise direction, while the Lux-timer mainshaft rotates in a counterclockwise direction. Inasmuch as the time-release device was designed primarily around the Lux timer, several design changes would have to be made in the time-release device in order to accommodate the King-Seeley timer. Also, the physical dimensions of the King-Seeley timer are considerably different from those of the Lux Minute-Minder, and these differences would necessitate additional design modifications in order to permit the use of the King-Seeley unit as an alternate.

Drawings, Specifications, and Operator's Manual

In addition to the effort described above under Phase II, detail drawings of the parts and assemblies of the Type 1 Time-Release device were prepared, and manufacturing, inspection, and packaging specifications were written. These were submitted to the Sponsor on January 6, 1959. Also, prior to the conclusion of the program, an operator's manual was prepared, and copies were submitted on September 9, 1958.

FUTURE WORK

No future work is contemplated on this device at the present time.

APPENDIX 1

LIST OF TIMING MECHANISMS STUDIED AND THE MANUFACTURERS

1. Lux Clock Manufacturing Company, Fairview Hill, Waterbury, Connecticut
    a. Lux "Minute-Minder" (#2428)
    b. Lux "Alarm Clock"
    c. "Venus" (#242)
2. Westclox Division, General Timer Corporation, La Salle, Illinois
    a. Westclox "La Salle"
    b. Westclox "Baby Ben" Alarm Clock (#321)
3. King-Seeley Corporation, 1st and Conklin Streets, Ann Arbor, Michigan
    a. King-Seeley Timer
4. United States Time Corporation, Park Road, Waterbury, Connecticut
    a. Alarm Clock (#33)
    b. Pocket Watch (#38)
    c. Wrist Watch (#21)
5. M. H. Rhodes Incorporated, 20 Bartholomew Avenue, Hartford 6, Connecticut
    a. Rhodes Timer (#1667)
6. Wm. L. Gilbert Clock Corporation, McClellan Road, Winsted, Connecticut
    a. "Gilbert"

7. E. Ingraham Company, Bristol, Connecticut

    a. "Corning"

8. Columbia Time Products, La Salle, Illinois

    a. "Keno" Alarm Clock

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